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In vivo evaluation of Apex NRG, a new apex locator, and its comparison with Root ZX

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Abstract

Aim: To compare the accuracy of root canal length measurements using a new apex locator, Apex NRG, and the known apex locator Root ZX.
Materials and Methods: A total of 64 root canals from 31 randomly chosen teeth were included in the study. The working length was determined using two apex locators, Apex NRG and Root ZX, and the results were statistically compared using One Factor ANOVA Scheffe F- test, p< 0.05.
Results: The apex locator readings were compatible (within ±1 mm) in more than 84% of the root canals. No significant differences were found between readings obtained by Apex NRG and Root ZX.
Conclusions: Apex NRG can be considered an accurate and reliable tool for length determination.

The endodontic literature deals extensively with location of the apical foramen (Kuttler, 1955) and determination of the biological apex and working length, as well as with their relationship to the success of endodontic treatment (Sjogren et al, 1990).

Traditional canal preparation techniques aim to retain the foramen as a natural barrier between the root canal and the apical tissues (Schilder, 1971). Although there may be differences in location, depending on the status of the pulp, whether vital or necrotic, instrumentation and obturation should not extend beyond the apical foramen (Wu et al, 2000).

Suzuki (1942) discovered that the electrical resistance between a file inserted into a root canal and an electrode attached to the oral mucosa registered a constant value of 6.5 KOhms.

Sunada (1962) introduced an electronic method for measuring the length of the root canal, using a direct current device. His tests were based on the finding that the electrical resistance between the mucous membrane and the periodontium is constant regardless of the patient's age or the shape and type of tooth involved (Sunada, 1962). Yet his results were inaccurate, particularly in the presence of fluids and in wide apical foramina (Huang, 1987; Fouad et al, 1993).

To overcome these shortcomings, improvements such as alternating current apex locators were introduced. These include the Root Canal Meter (Onuki Medical Co., Tokyo, Japan) and the Sono-Explorer (Hayashi Dental Supply, Tokyo). The major disadvantage of these apex locators is that electro-conductive materials in the canal may lead to inaccurate measurements, mostly shorter (Fouad et al, 1990). To avoid such shortcomings, third generation devices were developed; these use multiple electrical frequencies that require substraction (Endex, also known as Apit, Osada, Japan) or division (Root ZX, Morita, Japan) of impedance (Ingle et al, 2002).

Root ZX, based on the quotient impedance method, was introduced in 1991. The quotient is barely affected by the presence of electrolytes such as sodium hypochlorite, blood, saline, local anesthetics and pulpal tissue within the canal. Root ZX contains a microprocessor that corrects the calculated quotient so that the position of the file tip and the meter readings are directly related. The device performs with high accuracy and no calibration is necessary (Kobayashi et al, 1994; Kobayashi, 1995; J Morita Manufacturing Corp, 1996).

Shabahang et al (1996) visually compared the relationship of the tip of an endodontic file to the apical foramen, using a stereomicroscope in 26 vital teeth (from seven patients) designated for extraction. Root ZX located the apical foramen within ±0.5 mm in 25 teeth, with a clinical accuracy rate of 96.2%.

In in vitro experiments, Ounsi and Naaman (1999) compared the root canal length obtained using the Root ZX apex locator with the actual length, obtained when the extracted tooth was embedded in a saline gel to simulate the periodontium. Measurements were taken when the needle reached the 0.5mm mark and the apex mark on the meter. These measurements were then compared with a calculated reference length representing the real length of the root canal. Root ZX registered measurements within a range of 0.5 mm in 84.72% of the cases, but was unable to detect the '0.5mm to the foramen' position inside the canal 50% of the time (Ounsi HF, Naaman A, 1999).
Recently a novel miniature apex locator, Apex NRG (Medic NRG Ltd, Tel Aviv, Israel) (Figure 1), also known as SETapex (SET Germany), was introduced. The technology of this apex locator is based on Digital Signal

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The Apex NRG

Processing (DSP) technology and uses square, multi-frequency currents (Apex NRG Technical data, 2004). The device takes the basic analog signal emanating from the file and, before it is exposed to any distortion, converts it into a digital signal configuration, which is then analyzed. The readings are an average of the majority of the signals, extreme signals being deleted. This apex locator uses short cables, so that there is no need to enhance the analog signal, thus avoiding signal distortion. Apex NRG does not require calibration (Apex NRG Technical data, 2004).
The aim of the study was to test the in vivo reliability of a new apex locator, Apex NRG, and to compare the results to those obtained using Root ZX, its accuracy recognized under clinical conditions.

Materials and methods

The study was conducted in the Department of Endodontics at the Hebrew University – Hadassah, School of Dental Medicine and included 64 root canals from 31 teeth.

The randomly chosen teeth, 17 maxillary and 14 mandibular, were divided as follows: 13 anterior teeth, seven incisors and six premolars (total 19 canals) and 15 molars (45 canals).

The study was limited to vital and necrotic pulps; retreatment cases were not included. All teeth had closed apices. After administration of local anesthesia (if required), a rubber dam was placed on the tooth. Caries and existing restorations were removed and an access cavity was prepared. The root canal orifices were enlarged using Gates Glidden drills No. 2 and 3 (Mani, Japan) and the canals were irrigated using 2.5% sodium hypochlorite.

A preliminary radiographic working length estimation was obtained from a preoperative radiograph using the paralleling technique and subtracting 1mm from the distance between the coronal reference point and the root apex. The working length was determined using one of two apex locators, Apex NRG and Root ZX. A size 15 K file was inserted into the root canal, connected to the apex locator and the lip clip was attached. The length was measured according to the manufacturer's instructions. When the signal reached the blinking red light (apex mark), the file was retracted until a constant red light (0.5mm short) appeared (Apex NRG owner's manual). When neither device allowed electronic measurement, the canal was excluded from the study. Treatment was then performed according to the set WL.

Two examiners, residents in the Department of Endodontics, evaluated the results. Each operator independently evaluated the working length according to the procedures described. The results were analyzed by One Factor ANOVA Scheffe F- test, $p< 0.05$. The final working length was set as the reading obtained by the Root ZX. Further radiographs were taken upon completion of the treatment.

Results

A comparison of the values obtained using both apex locators for all cases is shown in Table 1. In one canal only (distal canal of #37), an electronic measurement could not be obtained by either device.

Root ZX failed to determine the length of the canal in a further three other canals (MB1 and MB2 of #26 and #11). All these canals were excluded from the study. The apex locator readings were identical for the two devices in 34.78% of the root canals and compatible (within ±1 mm) in more than 84 % of the root canals. In three canals the radiographs demonstrated readings beyond the radiographic apex.

Discussion

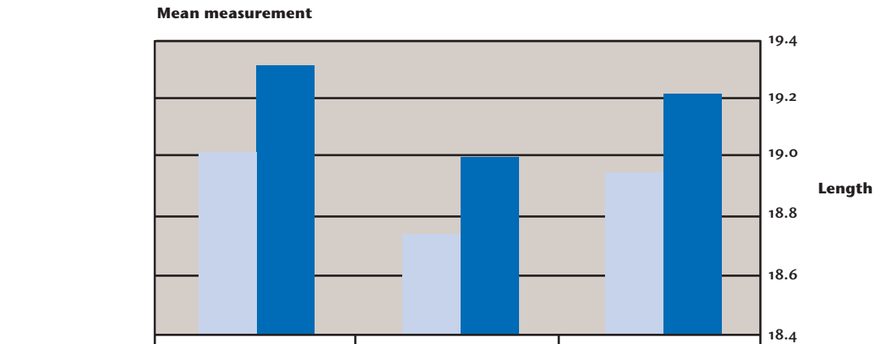
Previous studies used radiographs to assess the accuracy of electronic apex locators in vivo (Dunlap et al, 1998). Yet the position of the tip of the measuring instrument was not established in relation to the apical constriction (Dunlap et al, 1998). Furthermore, in vitro studies did not relate to errors that may have occurred while taking measurements in the oral cavity (Czerw et al, 1995). Indeed, as several studies have shown in more than 60% of the canals, the apical foramen is not located at the apex, and the distance between the apical foramen and the radiographic apex varies between 0-3 mm (Kuttler, 1955; Palmer et al, 1971; Burch and Hulen, 1972; Dummer et al, 1984).

Himel (1993) found that electronic and radiographic measurements agreed in only 34% of the cases treated by dental students. Similarly, Fouad and Reid (2000) found that Root ZX measurements and the radiographic measurements were identical in only 21% of the 58 canals tested. They set the radiographic length determination 1mm short of the radiographic apex. However, it was previously shown that the apical constriction (Langeland, 1998) and the apical terminus of the distal roots of mandibular molars, for example, are not always located at the radiographic apex (Tamse et al, 1988).

The method used in the present study accurately simulates the clinical conditions, unlike previous works in which the treated teeth were later extracted and the position of the file tip was then exposed (Welk 2003; Hoer and Attin, 2004). The method used on this occasion enabled a straightforward examination of the new electronic apex locator, Apex NRG, and the widely used Root ZX, which has previously been shown to be an accurate device (Shabahang, 1996).

As suggested by Fouad and Reid (2000), an initial estimate of the working length was made in order to reduce the number of radiographs taken. A #15 file was used in all treatments regardless of the canal width, following the findings of Nguyen et al (1996), who compared the length of enlarged canals using small size files and files matching the canal diameter to observe a possible discrepancy, and showed that the electronic

Table 1: Mean and SD of the working length measurements in the two experimental groups. There differences were statistically insignificant ($p>0.05$).



working length determination is not influenced by the size of the measuring file used. The apex locator readings were compared with the calculated radiographic working length, after preparation with Gates Glidden burs. It was previously shown that the ability to determine the apical constriction by tactile sensation was significantly increased when the canals were thus prepared (Stabholz et al, 1995).

In the present study, the apex locator readings were compatible (within ±1mm) with each other in more than 84% of the root canals.

Although electronic apex locators reportedly tend to locate a position that is, on average, slightly beyond the radiographic apex, these findings do not support this conclusion. In all cases the position of the file was further verified by a radiograph. Only in a minority of the cases (No =3) were the electronic apex locators readings longer than the radiographic length. The advantage of remaining within the limits of the canal without over-instrumentation or overextension of the filling material has been discussed by Sjörgen (1990).

The two apex locators produced compatible results, as shown in Table 1. There were very few cases in which both apex locators registered an unacceptable measurement. Apex NRG showed shorter readings than Root ZX. On the other hand, Root ZX, unlike Apex NRG, showed some 'null readings'. These results show that measurements obtained using Apex NRG are compatible with those of Root ZX and that Apex NRG may be considered a reliable apex locator.

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